CHAPTER 1

1.1 GENERAL INTRODUCTION

Worldwide concern for the possible repercussions of any future climate warming upon changes in coastal positions (Gornitz et al., 1982; Leatherman, 1989; Warrick et al., 1993; Kerwin et al., 1999) have provided a stimulus to coastal geomorphic work especially onshore ancient sedimentary deposits. Such sedimentary deposits are known to trap proxy signals along with datable material. Radiocarbon dating generally enables the construction of a very precise chronological framework for onshore deposits. Numerous proxies have been used to decipher the palaeo-oceanographic conditions. Parkin and Shackleton (1973) used Trade wind and temperature correlations down a deep-sea core off the Saharan coast to appreciate the palaeovariations. Likewise, Bucher (1977) used an oxygen isotope climate record from the Devon Island Ice Cap to decipher palaeo conditions. Tree rings too provide insights on the palaeoclimatic records (see LaMarche, 1982). Lorius et al., (1979) generated a 30,000 year isotope climatic record from the Antarctic ice. Similarly, Grootes et al., (1993) used the Greenland ice cores (GISP2-IP-GRIP) and studied Oxygen isotope records. Oxygen isotope stratigraphy of the late Pleistocene coral terraces too have been used to decipher the variations in palaeoclimate (Shackleton and Matthews, 1977). The deglacial sea-level record and the timing of the global melt-water discharge have been inferred from corals (Bard et al., 1996). Insect and plant macrofossils of Quaternary exposures too have been used to understand the climatic variations and sea-level change during Termination II (see Matthews, 1975 and Gallup et al., 2002). Shennan et al., (1983) drove an impetus in the analysis and interpretation of Holocene sea-level data in the early eighties. Bradley has brought out a summary of methods of Palaeoclimatic reconstruction (1985) focusing on
Quaternary Palaeoclimatology. Similarly, Scott et al., (1989) summed up the Late Quaternary Sea-level Correlation and Applications.

Significant progress has been made in Holocene sea-level research through the proposition and subsequent testing of models of sea-level change and coastal evolution (see for example Atwater et al., (1991), Long and Shennan, (1993 and references therein). Likewise, studies on Holocene crustal movements and sea-level changes have been demonstrated by Shennan (1989); Atwater (1987); Darienzo and Peterson (1990); Atwater and Yamaguchi (1991); Atwater et al., (1991); Savage and Plafker (1991).

The reconstruction of sedimentary facies architecture of the Late Quaternary depositional sequences can be considered a major tool in predicting the sedimentary response of coastal systems to such sea-level fluctuations (Belknap et al., (1994); Amorosi et al., (1999). Late Quaternary successions provide a good basis for high-resolution sequence stratigraphic analysis, because of the sea-level fluctuations during the Late Pleistocene and Holocene. Excellent theoretical work on global sea-level changes has been provided by Newman et al., (1989), Selivanov, (1991) and others.

Numerous workers have provided excellent records on Quaternary sea-Level fluctuations from varied geomorphic scenarios such as the coastal spits of Groote Eylandt, Australia (Shulmeister and Head, 1993), Holocene sand-shell ridges of the Bahia Blanca Estuary, Argentina (Aliotta and Farinati, (1990), Quaternary landforms of Scotland (Sutherland, 1984), Coastal landforms of Fiji (Nunn, 1990a), Vatulele-Bequa Ridge of the Yanauca Islands of the south Pacific Ocean (Nunn, 1990b), Romagna coastal plains of northern Italy (Amorosi et al., 1999) and the geomorphic response of Baltic sea coast to Holocene eustatic oscillations (Punning, 1987). Similarly, Kawana and Pirazzoli (1990) have re-examined the Holocene emerged shorelines in Irabu and Shimoji
islands, Japan. One of the marked features of late Quaternary/Holocene onshore deposits world over have been the studies on the occurrence of peat, beach rock (Littoral concrete), Chenier plains and shell deposits (see Hendry and Digerfeldt 1989; Ellison and Stoddart, 1991; Parkinson, 1989; Long and Innes, 1993; Punning, et al 1993; Punning and Koff, 1998.

A number of sea-level curves have been generated on global and regional scales and a number of quantifications of the sea-level fluctuations have been brought out (see for example: Fairbanks, 1989; Hashimi et al., 1995; Intergovernmental Panel on Climate Change, IPCC 2001; Gehrels et al., 2002; Pavlopoulos et al., 2006; Digerfeldt and Hendry, 1987; Nikitina et al., 2000; Ramachandran and McAndres, 2006; Papadopoulous and Tsimplis, 2006; including Sea-level changes due to Typhoons, Cho and Kim, 2006). More so, Larsen and Clark (2006) reviewed the search for “Scale in Sea-Level Studies”. In general variations palaeoclimatic conditions enforces changes in the sea-level both in time and space. Thus, studies on the palaeo-sea levels aided by dating techniques enable one to decipher the vertical and horizontal position of the ‘palaeo-sea level’.

1.2 The quaternary-Holocene scenario:

The Quaternary-Holocene scenario along the west and east coasts of India are well documented in the work of Banerjee (2000 and references therein) describing the east coast of India and the relative Holocene and Late Pleistocene relative sea level fluctuations. Imprints of late quaternary climatic and sea level changes on East and South Indian coast in terms of dating palaeo-beaches, shell deposits, palaeobeach ridges, sea-stacks, sea-caves, marine terraces, marine platforms using shells, peat/organic clays, wood/spores have been well represented in literature (Von Rad et al., 2006; Staubwasser 2006; Caratini et al., 1994; Caratini

1.2.1 The West Coast of India:

A large gap in literature on Quaternary sequences of the northern Kerala, exists- that warrants a detailed study, as this would provide new inputs to the regional scenario on the Quaternary response of the coastal tract (onshore sedimentary deposits) of the west coast of India. Extensive work concerning proxy signals for palaeo-shorelines, and ages of late Quaternary onshore sedimentary deposits have been carried out along the west coast of India (see for example Agarwal and Guzder, 1972; Gupta, 1972; Kale and Rajaguru, 1985; Merh, 1987; Bruckner, 1989; Nambiar, et al., 1991; Shankar and Karbassi, 1992, Nigam et al., 1992; Hashimi et al., 1995; Pandarinath et al., 1998; and references therein).

Holocene marine transgression of the central west coast of India has been attempted by many (see for example Caratini and Rajagopalan 1992; Tissot, 1990; Caratini, et al., 1990; Caratini et al., 1994). Detailed underwater surveys has been carried out in the Gulf of Cambay, about 20 km west off Hazira, in the Arabian Sea, the presence of a submerged palaeochannel, traceable to a length of 9 km associated with stone artifacts, potsherds, hearth pieces, animal bones and human teeth embedded in fluvial sands and silts and in the upper part of the deposit, a carbonised wooden log was found and dated to around 9500 years BP by super (14) C method. This appears to be one of the early records of prehistoric human activity of early Holocene age in the marine environment of India. Extensive work on the onshore deposits of Gujarath coastline does exist. Gupta (1972) worked on the raised beaches and Inland Coral Reefs. Hussain et al., (1980) have brought out the ages of the Miliolites sea level fluctuations of the Indian coastline by marking terraces and correlated them with the classical Mediterranean
stratigraphy; today altimetry alone is not a useful indicator for chronosequences of marine terraces (Bruckner 1985). Though Chatterjee (1961) was one of the earliest to deal systematically with the effect of the Quaternary, Bruckner (1989) has evaluated the late Quaternary shorelines in India with special emphasis on the onshore deposits and their radiometric dates.

Stoddart and Gopinandha Pillai (1972) have studied the 'Raised Reefs of Ramanathapuram, on the east coast of India. However, not much of a record exists for the northern Malabar Coast (SW coast of India) as could be observed through the work of Krishnan Nair, (1987), Nair, (1987). Rajendran et al., (1989). Bruckner (1989) worked on the southern part of the Kerala Coast focusing on the nature of subsidence.

In general, extensive work focuses on extracting proxy signals (representing the Quaternary) from sedimentary cores from the shelf and deep-sea off India exists (Sirocko, et al., 1993; Nambiar et al. 1991; Shankar, and Manjunatha, 1995 and references therein; and others).

A lot of focus on offshore proxy data reflecting on the Quaternary palaeoclimate focusing continental shelf and deep-sea sediment cores, palaeo submerged beaches, pollen records with proxy and multi-proxy approaches towards the reconstruction of palaeosea-levels and palaeoclimate could be observed in more than a couple of hundred publications (see for example: literature cited in Raghav and Malmgren, 2006; von Rad et al., 2006; Staubwasser 2006; Staubasser, et al., 2002; Naidu and Shankar, 1999; Sriram et al., 1996; Prabhu, and Shankar, 2001; Rghunath et al., 1995; Caratini et al, 1994; Manjunatha and Shankar, 1992; Shankar and Korbassi, 1992; van Campo, 1991; Duplessy, 1982) that reflect the focus on the offshore signals and the lack of a focus on the onshore deposits that provide datable material.
However, research on late Quaternary onshore deposits of northern Kerala presents an excellent attempt to reconstruct the coastal geomorphology, however the rather sparse work representing the area constrains the discussions as could be observed in the work Agarwal et al., (1975-79) who worked on the proxy data of Vembanad Lake and Cochin Harbour. Pawar et al., (1983) presented some new data of the time by working on the decayed wood east of Vaikkom. Paulose and Narayanaswamy (1968) attempted to reconstruct the Quaternary history of the area. It was Rajendran et al., (1989) who contributed enormously by working on the sediments of Payyannur, Vechur, Muhanna, Tellicherry and Tannisseri. However, descriptive material was indeed sparse in the work cited above. Yet, the work in diverse places cited above indeed opened the doors for fresh thought, signaling the need for a revisit to the evolutionary aspects geomorphology with fresh $^{14}$C dates and modern techniques of cartography and remote sensing. Thus, the Quaternary has impressed upon our coasts numerous and subtle proxy signals that could spell the process-response behaviour of the morpho-sedimentary environments of the coasts to fluctuating sea-levels.

1.2.2 Objectives of the Present Study:

It could be observed form the foregoing presentation, that most of the earlier workers focused on offshore deposits to describe the late Quaternary history of the SW coast of the Indian peninsula. A major constraint- being the publications that were sporadic spread over fourteen years (1975-1989) and hence less comprehensive and holistic in evolutionary aspects. The area still lacks a chronology constrained descriptive geomorphologic presentation.

Hence, this work envisages providing a regional geomorphic description of the evolution of land-forms. There is an attempt here to reconstruct the sea-level fluctuation scenarios constrained by radiometric
dates of this study and dates already published. No work in evolution is complete with the presentation of the nature of the 'modern' beach. Hence a chapter on the nature of the modern beach is provided, which is the ultimate response to geomorphic evolution of a coastal tract.

1.2.3 Area of Study:

The study area (Fig. 1.1 & 1.2) is located on the west coast of India, in the north part of Kerala State, commonly known as the 'Malabar' region. Precisely, the study area represents the southern sector of the Malabar Coast and hinterlands. The area experiences intense tropical climatic conditions providing the famous laterites as construction material for houses etc. The Arabian Sea is to the west of the study area with the lofty Western Ghats, technically the scarps and ridges of the upraised regional peninsular Karnataka-Kerala-Tamilnadu Plateau. The coastline is in regional alignment (NNW-SSE) with the west coast of India and is crescentic with pocket beaches being uncommon. Excellent transport network exists and is represented by National Highway 17, and the Railway running north to south. Numerous state highways and motorable roads exist towards the west in the study area. The province of Kerala is historically famous for export of spices, timber and cotton garments. Fishing is a principal occupation, along with boat building. The demography is more represented by women and the region has one of the oldest synagogues, temples, and churches. Kerala is often referred to ".....God's own country". Tourism being one of the large revenue earners.

1.3 Geology of the Study area

The geology (Fig. 1.3) of the Vengara terrain represents a part of the high grade areas of peninsular India and contributes as an important part of the South Indian Precambrian terrain made up of the Archaean
continental crust, such as gneiss, granitoids and granulites. Geology indeed is not the focus of this work; however, geology is brought out as an expression of the evolutionary history of the Vengara terrain. Cenozoic sediments, both marine and non-marine, lie unconformably over the Precambrian rocks. In general, Raghavan (1988), Udayashankar (1994), (Soman, 1997), divides the western seaboard region of Peninsula India into two major tectonic provinces, namely, the Precambrian province comprising of the higher mountainous scarps of Western Ghats with the pediplains and Greenstones punctuated with younger granites and older granitic plutons and the Tertiary tectonic province, a narrow belt of coastal and midland regions, consisting of younger and older sedimentaries and laterites of varying ages. Both provinces extend from north of the west coast India to the southern tip of Kerala State. The study area largely follows the regional trend of NW-SE including the tectonic signatures. Evidences for erosional and depositional histories of the terrain is preserved in the low land areas and coastal plains, which records a total of 70% (see Nair et al., 2006 and Resource Atlas of Kerala, 1984) of the total area of Kerala on the southern west coast of India. This pluton is emplaced within the Sargur-equivalent sequence of the study area reflecting the gabbro tonalite-trondhjemite granite suite (Sinha-roy and Radhakrishnan, 1983). The Pluton is located southwest of Ezhimala town close to the WNW end of the Bavali lineament with a maximum exposure length of 6 km and a width of 3 km. The host rocks are gneisses with enclaves of sillimanite-kyanite schists, quartzites and metamorphosed ultramafic rocks of the Manantoddy Formation (Nair and Vidyadharan, 1982). The exposed part of the pluton contains gabbro, often grading into leucogabbro in the east and south. At the northern end of the pluton, a narrow zone of xenoliths of mylonitic and well-banded quartzite, quartz-mica schist, vein quartz and fine-grained amphibolite. Sinha-roy and Radhakrishnan (1983) are of the opinion that the Ezhimala Pluton is emplaced in the gabbro. Basic dykes (see Lineament Map Fig. 3) occur in all rock units, and show a preferred NW-SE orientation, parallel to the coast line. However towards the pluton, the lineaments picked up
from IRS-IC LISS III satellite data radiating lineaments too could be observed from Ezhimala Pluton, probably caused during the emplacement of the pluton. In general, the Ezhimala pluton is one of the classic younger plutons of peninsular India. This pluton assumes a shore parallel ridge and is capped by a peak known as the Mt. Dilli. Many workers have attempted to decipher the geochronologic regime of the pluton (see. Nair and Vidyadharan (1982); Nair and Santhosh (1984); Nair et al., (1985), Nair and Vidyadharan (1982) have an Rb-Sr isochron age of 678 Ma for the Ezhimala granophyre pluton, located in the southwestern (Mt. Dilli) part of the study area. Charnockites and associated gneisses are the most regionally widespread rocks of the study area (Nambiar et al., 1991; Soman 1997). Soman (1997) determined age of charnockites as 2155-2930±50 Ma. Charnockites along with narrow bands of pyroxene granulites and magnetite-quartz rocks are the most widespread group area over which lies the ancient and modern sedimentaries. The regional dyke distribution of rocks of the region and is most common rock type forming the basement in the study is well represented in the study area and is well exposed in the central part of the study area and to the northeast and northwest. The Palachal dyke is an older basic dyke of the Cannonnore region and is coarse-grained and consists of plagioclase, orthopyroxene and clinopyroxene as the principal mineral constituents (Soman, 1997). The genesis of doleritic dykes, with strong regional implications, younger in age (61-144 Ma) imprints the regional basement of the area. It is of interest to note that basic dykes cut across the foliation and other structures of gneisses and charnockites with trends of NE-SW, with ages of 144 ±6 Ma and the NW-SE trending dykes are younger with ages of 101-107±5 Ma (Sinha-Roy and Radhakrishnan 1983; Radhakrishna et al., 1990) NW-SE dolerite dykes cross-cut the NNW-SSE dykes and have an emplacement age of 61±9 Ma and are thought to represent a precursor magmatic event (Radhakrishna et al., 1990; Radhakrishna et al., 1994).
Fig. 1.1 Study Area
Fig. 1.2 SATELLITE IMAGERY OF IRS –IC, LISS-III 1998, DIFFERENT LANDFORMS IDENTIFIED IN THE STUDY AREA.
Fig. 1.3. Geology of the study area
The Archaean Supracrustals consist of the greenstone sequence and is represented by the Wayanad Group and Vengad Formation. The Wayanad Group consists of bands of quartz-mica schists with Kyanite, quartz-sericite schists, quartz-magnetites, quartzites, meta-ultramafites and metapyroxenites in various stages of migmatisation (Soman, 1997) and they trend NNW-SSE and are well exposed at Taliparamba and Payyanur in the study area. The rocks of the Vengad Formation apparently overlying charnockites, gneisses and high grade schists of the Wayanad consists of schists and quartzite with a conglomerate at the base. The Vengad Formation and the Wayanad Group depict folding in the NNW-SSE and NE-SW respectively. The Anorthosites are nonlayered and highly deformed with very coarse-grained plagioclase laths crudely aligned in the general E-W direction. Pseudotachylyte veins are observed in the anorthosite massif suggesting the massive tectonic events that occurred in the evolutionary history of the terrain. The oldest rocks of the region belong to the Precambrian charnockite-gneisse series and have recorded ages of 2155-2930±50 Ma, representing various episodes of the Archaean and Proterozoic (Soman (1997). Proterozoic alkaline intrusives record an age of 505-765Ma. A classic episode of the genesis of doleritic dykes, with strong regional implications, younger in age (61-144Ma) imprints the regional tectonics of the area.

Digital image processing proved that remote sensing is useful in mapping lithology and offers an efficient tool for detecting geological structures such as lineaments. The filtering technique is commonly used to (i) restore imagery, (ii) enhance the images for visual interpretation and (iii) extract features using local spatial frequency. The directional filter is a spatial filter very useful for detecting the oriented features such as lineaments and emphasizing higher spatial frequencies. Most lineament maps have been drawn based on fieldwork by experts and visual analysis of enhanced image data. In visual interpretation and mapping of lineaments, geologists use their knowledge and experience to extract the lineaments from the curved and straight lines in image data Tripathi et
A lineament map (Fig. 1.4) depicts the lineaments extracted from IRS IC LISS-III digital data using ERDAS 8.5 image processing software. Sobel filtering technique is used to highlight the linear features. It could be observed that the lineaments largely follow the regional trend of NW-SE. Radiating lineaments could be observed from Ezhimala, probably caused during the emplacement of the pluton. Numbers are elevation in meters above MSL extracted from SOI toposheets as Spot-heights, Benchmarks and Ring Contours etc. This work would address/provide for the following objectives:

- To construct a modern 3-d geomorphologic map using wire-mesh techniques.
- To construct a land-use/cover map using satellite digital data.
- To furnish evidences and establish the occurrence of palaeosurfaces (planation surfaces) in the study area.
- To provide evidences of an onshore marine sedimentary deposit.
Fig. 1.4. Lineament map of the study area extracted from IRS-1C, LISS III using ERDAS image processing techniques (Sobel etc). Note the lineaments largely follow the regional trend of NW-SE. Radiating lineaments could be observed from Ezhimala; probably caused during the emplacement of the pluton. Numbers are elevation in meters MSL.
References


Matthews, J. V. (1975) Insects and plant macrofossils from two Quaternary exposures in the Old Crow-Porcupine region, Yukon Territory, Canada. Artic Alpine Res. 7, 249-259.


